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APPROPRIATE DESIGN AND APPLIED TECHNOLOGIES FOR THE DEVELOPMENT OF HUMAN SETTLEMENTS INFRASTRUCTURES IN AFRICA

LC/NAIROBI

Introduction

1. The provision of adequate shelter in decent human settlements is a major concern of governments of member States in Africa, and also engages the attention of many international and non-governmental organizations operating in the region. It is well recognized that the kind of human settlements needed to promote the well-being of residents and enable them to participate actively in the local and national social and economic life means more than the mere provision of housing units. Basic infrastructures such as water supply, electricity, sanitation facilities, roads and transport facilities, as well as other services like health and education are all necessary to ensure the completeness of life in human settlements. In fact, the Global Strategy for Shelter to the year 2000 adopted by the Commission on Human Settlements at its 11th Session in April 1988 stressed that the provision of water supply and sanitation services in adequate quantities will be a key input to the production and improvement of shelter.

2. In many countries of the region, water-borne and excreta related diseases such as cholera, bilharzia, diarrhoeal diseases, infectious hepatitis and typhoid fever, constitute the greatest health hazard, causing high mortality, widespread morbidity and extensive loss of vitality resulting in low productivity. The improvement of both water supply and sanitation services, coupled with personal and environmental health education, is essential for achieving better health conditions within human settlements. The current situation in the region however reveals the need to take urgent measures towards achieving improvement in all these areas. Rural areas and slums and squatter settlements in the urban areas are the worst affected in the provision of human settlements infrastructure and therefore deserve the greatest attention.

3. The cost of providing basic infrastructures for the majority of the population in African countries is enormous. And viewed against the background of the chronic economic problems faced by most member States, reliance on the use of conventional approaches to the provision of human settlements infrastructures would only lead to a perpetual widening of the gap between service demand and the supply. Efforts are continuing in some African countries as well as in other countries in the developing world to develop infrastructure technologies that are better suited to the local social, technical and economic conditions, thereby contributing to the improvement of infrastructure coverage in both the urban and rural areas.

4. The purpose of this document is to review some of the available technologies for infrastructure development with special reference to water supply and sanitation facilities, examining experiences emanating from their application and then outlining some criteria for the selection of appropriate design and construction technologies. Recommendations for action at the national, regional and international levels are proposed to stimulate renewed commitment and action towards an improvement in basic infrastructure provision in human settlements through the optimum utilization of available resources.

Water supply

5. In 1983 about forty per cent of the population in Africa had access to safe drinking water, compared with the global (world) average of 52%. Predictably, the urban areas were better serviced than the rural areas. Almost 60% of the African urban population were served while in the rural areas, where over 70% of the total population live, only 30% of the inhabitants had access to safe drinking water. In a survey of community water supply needs in Africa conducted by ECA it was found that whereas 30 of the 41 countries surveyed provided water to over 50% of the urban population, only 5 had been able to achieve the same level of coverage in the rural areas 1/. The survey also revealed that while some countries had shown improvements in water supply coverage from 1970 to 1983, in others, the provision of water had not kept pace with population increases, resulting in a reduction in service coverage over the same period.

Urban water supply

6. In the cities and large towns, centralized water supply systems constitute the main source of potable water with house connections being provided in most medium and high income zones. Yard taps and standpipes meet the water requirements of the bulk of the population in low-income settlements. Slums and squatter settlements are generally poorly served and this, added to the poor quality of sanitation facilities creates very unhealthy conditions in such settlements.

7. In a low-income housing project in Addis Ababa (Ethiopia), the water supply network was designed to supply every plot in the future, but initially only one public tap was built to serve 50 households. The cost per plot of the public tap was about $US 70.00 which was half the cost of providing private connections. As the incomes of the residents improve they could opt for private connections. In order to ensure recovery of the cost of investment as well as the water consumption cost, a practical system has been evolved whereby public fountains are fenced, opened 8 hours a day by a guard, and consumers pay a fee on the spot as they collect the water. The system has operated satisfactorily and vandalism has been minimal because of the locked fence. 2/

8. Reliability is an important desirable quality of water supply systems. In Africa however, reliability is often very much affected by lack of effective maintenance practices. Apart from causing fluctuations or failures in the supply system, poor maintenance is also known to be the cause of impurity in water and losses in the distribution systems in the metropolitan areas. It is estimated that 20-40% of water is lost in the distribution system because of leakages. Improved maintenance, renovation and replacement of critical elements in water supply installations are essential in order to minimize water losses.

9. In Seychelles, for example, PVC, asbestos-cement and galvanized steel pipes which perform very well in some environments, were found to be unsuitable. Studies showed that cement-mortar lined ductile iron pipes performed better and have therefore been chosen as standard, for both water supply and sewerage. At the same time the institution of a simple leak detection programme has also reduced unaccounted water from over 40% to about 20% of production. 3/

Rural water supply

10. The rural water problem translates into three important dimensions, namely: distance form water source, quantity and quality. In many settlements the water sources are far away and women and children spend several hours a day fetching enough water to meet the family's needs. A study of the impact of 8 self-help water supply schemes in Tanzania showed that the improvement which the villagers liked most was the reduced distance from the house to the water source. The second most frequently mentioned item was better quality, primarily in terms of taste and appearance. This improvement was due to a better water source being tapped rather than water treatment. The benefit of greater quantity of water available was hardly mentioned, and the actual amount of water carried home did not seem to have increased appreciably with the building of the new schemes. 4/ An important consideration in improved rural water supply should therefore be to bring the water close to the settlements.

11. The low cost and simplicity of handpumps have made this technology attractive to governments and international development agencies seeking maximum impact from limited financial resources in rural community water supply. In several African countries, for example, Burkina Faso, Ethiopia, Ghana, Kenya, Malawi, Tanzania and Zambia, rural water projects based on hand pumps have been implemented. A major problem has however, been that once the pumps are installed there tends to be very little maintenance with the result that between 30-80% of the handpumps installed in the African region are out of operation at any given time. Several factors have been identified as being responsible for this situation. These include the following:

i) Poor quality of design and manufacture;
ii) Use of a large variety of handpumps with the accompanying need for spare parts which may not be easily available within the country,
iii) Poor maintenance skills, lack of training, inadequate tools, and sometimes inadequate means of transport for maintenance teams.

12. In view of the great potential benefits from the widespread use of handpumps, the World Bank sponsored a five-year project in which an intensive study was undertaken of handpump performance in laboratory and field conditions. The study covered 17 countries in the developing world and involved 2,700 individual pumps of 70 different models. Based on the result of this study and on information collected from rural water supply projects throughout the developing world, the following guidelines were proposed for the design of pumps for rural application:

i) Ease of maintenance: The design should be such that the replacement of all wearing parts can be undertaken by a village caretaker after a minimum of training and with only a few basic tools;

ii) Robustness: Non-wearing parts should be robust and durable, able to resist vandalism, climatic conditions and corrosive or sand-laden water;

iii) Local manufacture: Design should facilitate local manufacture from widely available materials, thus also enhancing availability of spare parts;

iv) Standardization: The adoption of a limited number of pumps will facilitate the training of caretakers and mechanics, and promote establishment of local manufacturing, enforcement of quality control and supply of spare parts;

v) Costs: The pumps should be low in capital and recurrent costs;

vi) Discharge rates: The pump models should be designed for specific ranges of pumping lift, with discharge rates selected accordingly.

13. Table 1 gives a summary of the various options that are available for community water supply schemes. While the ultimate target should be to bring water within easy reach of everyone, preferably with connections to individual households, constraints of financial, physical and organizational resources make it impractical to achieve this goal in the African region by the turn of the century. Consideration of technological choice which open up opportunities to reach out increasing numbers of the population in both the urban and rural areas should continue to be paramount in the decisions of planners and engineers.

Sanitation facilities

14. Comparatively, the provision of sanitation facilities particularly for human waste disposal in African countries is worse than it is for water supply. In 1983, only 29% of the total population had access to decent human waste disposal facilities. The situation in the urban areas was better than in the rural areas with 55% and 18%, respectively, being served with such facilities. There were, however, wide variations in service coverage

among the various countries. For example, while only 14(out of 41) countries reported adequate sanitation facilities for more than 50% of the urban population, only three countries (Mauritius, Libya and Tunisia) indicated 100% coverage. On the other hand 4 countries had less than 10% coverage. In the rural areas, as many as 18 countries had less than 10% coverage while only 5 countries reported a rural sanitation coverage of over 50%.

15. The present level of provision of other sanitation facilities including solid waste disposal and drainage, which all have very important consequences for health in human settlements, is also inadequate. The problem is more critical in the poor high-density sectors of cities and other large towns where shelter conditions are also generally deplorable.

Sanitation technologies

16. Table 2 gives a descriptive comparison of sanitation (human waste disposal) technologies which would be appropriate under different prevailing conditions in the urban and rural areas. It covers such items as construction and operation cost, self-help potential, water requirement, appropriate soil conditions and institutional requirements for operation and maintenance. Socio-cultural factors also play an important role in the selection of sanitation technologies. Almost all the listed technologies are used in various African countries. The main characteristics of some of these technologies are described below together with an indication of the experiences associated with their usage.

Pit latrine

17. Pit latrines are the most common human excreta disposal facility in developing countries, including Africa. The pit latrine consists essentially of three components, namely: a pit, a squatting plate and a superstructure. When the latrine is filled, the superstructure and squatting plate are removed, the pit is filled with soil and a new pit is dug. While it is low-cost and requires only semi-skilled and unskilled labour for its construction, the pit latrine has two main disadvantages: it usually smells and encourages the breeding of flies and mosquitoes. A potential hazard associated with pit latrines is the possible contamination of groundwater and thus disease transmission to users of well-water.

Ventilated improved pit (VIP) latrine

18. This is essentially a conventional pit latrine provided with a vent pipe which helps to overcome the deficiencies of bad smell and flies. The top of the vent pipe is covered with wire gauze to prevent the escape of house flies and mosquitoes which are inevitably bred. The pipe is also painted black and placed on the sunny side of the latrine to allow air inside it to heat up and create air circulation via the squatting plate opening.

Ventilated improved double pit (VIDP) latrine

19. In order to avoid the construction of another latrine once the pit is full, and to facilitate the emptying of the pit where space for a replacement latrine does not exist, a double pit latrine is used. The ventilated improved double pit(VIDP) as it is called, ensures that one pit is always available for use. When it gets full, it is sealed while the second is put into use. When the latter is almost full, the first pit is emptied and put back into use once more. In this way the two pits can be used almost indefinitely.

20. Ventilated improved latrines have become very popular for application in both urban and rural areas in several African countries, and are being widely used, for example, in Botswana, Ghana, Tanzania and Zimbabwe. In Ghana, the University of Science and Technology has developed a 10-seater version, called the K-VIP for communal use.

Reed odourless earth closet (ROEC)

21. The Reed Odourless Earth Closet is another improved pit latrine. It incorporates the use of a chute which channels excreta and urine into a chamber located at the rear of the superstructure. This overcomes the problem of the superstructure collapsing into the pit. The other advantage is that its contents can be emptied by removing the access cover at the rear of the superstructure. This system is common in Botswana and Tanzania where experience has shown that it is easily subject to fouling by excreta particularly during the cleaning of the chute. This has led to the development of a modified design in which the chute is eliminated, and the near end of the pit is extended just below the superstructure so that the excreta from the squatting slab can drop directly into the pit.

Aqua privies

22. The conventional aqua privy essentially consists of a squatting plate situated above a small septic tank that discharges its effluent to an adjacent soakaway. A drop pipe which is an integral part of the chute and

extends 10-15cm below the water level in the tank forms a simple water seal that prevents odour and flies in the toilet. Periodic desludging of the tank is necessary, usually when it is about two-thirds full. The system's efficiency depends on the maintenance of the water seal but experience from many countries shows that the seal is rarely maintained, except in cultures where the tradition of anal cleansing with water is prevalent, and this results in a high rate of intermittent malfunction. As a means of overcoming this problem, the self-topping or sullage aquaprivy was developed. The design provides for the addition of all household sullage to the tank, thus the water seal is readily maintained and the sullage is conveniently disposed of. In sewered aquaprivies, the use of soakaways is eliminated by discharging the effluent directly into sewers.

23. The different types of aquaprivies are used in a number of countries including Nigeria, Zambia, Zimbabwe, Botswana and Ethiopia. Apart from the common problem of failure to maintain the water seal cited above, other operational and maintenance problems have included, failure of soakaways due to impervious soil which is easily clogged with organic matter, blockages of vertical pipes discharging sullage into the tank (in self-topping aquaprivies), technical problems of ensuring that the tank is watertight and, the periodic emptying of the tanks has not always been well-programmed and undertaken.

Septic tanks

24. Septic tank systems are used in virtually all capital cities of the African region in low/medium density settlements. The conventional designs are intended for houses that have an in-house water supply and sufficient land for effluent disposal. The main problem with the use of septic tanks relates to desludging which is usually carried out by the municipal authorities. Overspilling of tanks to surrounding grounds is therefore not uncommon. The high cost of the system limits its use to relatively high income households.

Conventional sewerage systems

25. These provide the most convenient method, from the user point of view, for handling human excreta and household wastewater especially where the population exceeds 500,000. They are convenient, pose no risk to health when functioning properly, require minimal municipal maintenance and in general, operate with few service interruptions or emergencies. The systems are however, very expensive to construct, operate and maintain. They require a substantial amount of water and a water use of about 75 litres per capita is necessary to avoid blockages. The high cost of conventional sewerage systems have prevented large segments of the population, even in the cities where they are used, to benefit from the high level of service they provide.

A 70km sewerage network for Addis Ababa (Ethiopia) started in 1982 at a cost of about $US 12 million, would only serve just about a quarter of the city's population of nearly 1.5 million.

Shallow sewer systems

26. This is a recently developed sewerage system which holds promise for use in high-density low-income settlements where water-dependent human excreta disposal facilities are installed. Shallow sewerage eliminates the public health risks usually associated with inadequate excreta and waste-water disposal at relatively lower cost. A study of the total annual cost per household of various sanitation options found that shallow sewers were cheaper than even on-site sanitation systems at settlement densities in excess of 160 persons per hectare. 6/

27. Shallow sewer systems consist essentially of a network of small diameter pipes laid in shallow trenches away from heavy imposed loads, with small inspection chamers provided along their lenths to facilitate access for maintenance. Several houses are connected to the same sewer which when it emerges from the block, can be connected to a conventional street sewer, or discharged into a communal septic tank or discharged straight into ponds.

28. The system, which was first developed in Brazil and has been applied in squatter settlements and planned housing schemes in that country, has also been used successfully by the United Nations Centre for Human Settlements (Habitat) in a community development project in a spontaneous squatter settlement in Karachi, Pakistan. The shallow sewerage system requires a minimum average water consumption of at least 25 litres per capita per day for the sewers to operate without blockages. There is also no experience on which to assess its suitability in areas where bulky anal cleaning materials are used. There is no record of its use in an African country but it provides a technological option which can be considered alongside others, where favourable conditions exist.

Solid waste disposal

29. Another aspect of sanitation which requires attention concerns the disposal of solid wastes. This is more of a problem in urban areas than in rural areas where because the production of waste is low and there is plenty of land to assimilate dumped material, the need for a formal system of collection and disposal is minimal. In urban areas, there is the tendency for indiscriminate dumping of wastes - at street corners, in drainage ditches and river courses. In the low-income sectors of most urban areas, refuse collection points are located by the municipal authorities, who also organize the final collection and disposal from the dumps. Experience from several

cities shows that because of poor organization and inadequate vehicular support, the refuse very often decomposes at site, creating unpleasant odours and providing a suitable habitat for disease carriers such as rodents and flies.

30. The other common form of solid waste disposal which is used more in medium and high-incomes zones of urban areas, is the system where sanitary drums are placed at vantage locations for communal or individual use, and emptied periodically by municipal trucks for final disposal. An alternative system, practiced, for example in Addis Ababa, Ethiopia, depends entirely on the use of garbage trucks which serve specific locations. When the truck arrives, a horn is blown and residents carry their garbage directly to the truck for final disposal. Thus, no communal refuse dumps are used.

31. A recurring problem with these solid waste disposal systems is the perennial shortage of trucks to collect the waste for final disposal. Another deficiency observed in some cities is the limited number of final dump sites and their distance from the city which allows trucks to make only a few trips per day. Thus in many cities only about 50% of the garbage generated is collected.

32. The solid waste management systems in most cities and urban centres in Africa are unable to cope adequately with the rate of waste generation and therefore require improvement. It is important to review the current situation with respect to the technologies used as well as the managerial, institutional and financial support systems in order to identify deficiencies and define suitable technological options.

Drainage facilities

33. The importance of adequate drainage facilities in human settlements derives from the need to dispose of waste water from dwellings and also storm water, thereby avoiding the incidence of stagnant water with its attendant health hazards, and also flooding during the rainy season, which leads to loss of life and property. While the provision of drainage facilities in the cities and other urban areas is inadequate in many countries of the region, the slums and squatter settlements which are mostly unplanned, are worse off. These areas are usually the worst affected after heavy downpours of rain. The improvement of drainage has therefore featured prominently in sites and services and slum upgrading projects.

34. Poor maintainance of street drains in cities usually renders them ineffective for the purpose for which they were provided. Silted open drains, which continue to be targets of dumping of all kinds of refuse by pedestrians as well as from households in adjoining properties can be found in many cities around the region. The incidence of flooding reported in cities in the recent past, draws attention of planners, designers and decision makers

to the need to take a comprehensive look at existing storm drainage systems, with a view to adopting improved planning, design and construction technologies which will limit the adverse effects of heavy and continuous downpours of rain in the future.

35. Lack of adequate drainage facilities also affects the stability of buildings in settlements and in the rural areas underscouring of buildings caused by uncontrolled flow of both waste water from households and rain water is a prevalent occurence. The provision of a simple network of properly designed earth drains, maintained by the local communities, would not only help in protecting the foundations of earth buildings which are popular in rural areas, but would also help to improve the general sanitary conditions within settlements.

36. Lack of drainage facilities also leads to the rapid deterioration of roads, and in rural areas where unpaved roads are frequent, poor drainage is the single most important factor that affects the serviceability of roads. The provision of both parallel and cross drainage facilities, as well as their proper maintenance, is essential to improve road accessibility as well as transportation services in rural areas. Design concepts that promote the utilization of local building materials in the construction of drainage structures should be promoted.

Selection of appropriate design and construction technologies

37. In general, the selection of an appropriate technology is based on a combination of economic, technical and social criteria. Very often, for example with respect to water supply and sanitation services in a rural context, these considerations reduce to the question: What is the least expensive, technically feasible technology that the users will accept and would be able to maintain and that the local authority is institutionally capable of operating? Even for road infrastructure for which users may not make direct payments, the involvement of local communities in the construction and maintenance of sections of road passing through their settlements could still be critical for achieving maximum benefits from the investments made.

38. Past experiences from the design, construction and maintenance of human settlements infrastructures, provide a guide in the selection of appropriate technologies that would promote the optimum use of available resources for infrastructure development to enhance the quality of life in both urban and rural human settlements. Some of the important considerations in this selection are outlined below:

Stage construction

39. The design of infrastructure should provide for upgrading the level of service in accordance with increasing resource availability and service demand. For example, Tables 1 and 2 give various options for community water supply and sanitation technologies. Within these options there is the possibility for upgrading or replacing technologies with those providing a better level of service. Fig. 1 gives a schematic representation of potential sanitation sequences and improvements depending on the level of water service. An important consideration at any stage of improvement should not only be the mere availability of increased financial resources, but also the availability of the required human and organizational resources to sustain the new technology.

40. The concept of step-by-step improvement is also valid for other infrastructure like road networks. In this connection it is important to ensure that an adequate right-of-way is reserved in the physical plans to eliminate, for example, the payment of compensation for properties that might have to be demolished to make room for the expanded facilities.

Sustainability

41. A recurring experience in the provision of infrastructure in African countries is that due to poor scheduling and implementation of maintenance activities, many facilities soon fall into disrepair leading to wastage of scarce financial resources. Many factors contribute to the maintenance problem, including inadequate financial resources, unavailability of equipment and spare parts, and lack of suitably trained technical and managerial personnel. Experience has shown, for example, that one of the primary considerations in designing and building a rural water supply project is to keep the technology as simple as possible so that local operators will be able to operate and maintain the system for long periods of time in the absence of an engineer. Selected equipment should have a good record of performance under similar climatic and socio-economic conditions.

42. It is important therefore at the planning stage to assess the maintenance requirements and the availability of resources to sustain the different technological options. Anticipated problem areas should be provided for at the project design stage. For example, training of maintenance personnel should be programmed, if found to be crucial to the successful operation of the infrastructure. The possibility of community involvement in the operation and maintenance of the infrastructure should be investigated. Another problem area of sustainability relates to effective organizational structures to collect user charges and organize maintenance activities. This should also be given special attention in technological choice.

Maximum utilization of locally available resources

43. The dependence on imported inputs-equipment, labour and construction materials for infrastructure projects has not only been a strain on scarce foreign exchange resources, but has also promoted the adoption of technologies which have been expensive and difficult to sustain. Appropriate design and construction technologies should now focus more on maximizing the use of locally available resources. The benefits of this approach to technology selection are many and include the following:

i) reducing project costs through the use of less expensive materials whose better supply would also reduce idle time at work sites caused by shortages in conventional construction materials;

ii) developing capabilities of indigenous construction firms by providing opportunities to undertake projects based on simple construction techniques;

iii) providing employment opportunities for local labour whose skills could be developed on the job to be applied to more difficult tasks on future projects;

iv) building up a body of design concepts and principles which are responsive to the local technical, economic and labour situation, thus contributing to the attainment of self-reliance in the design and implementation of infrastructure projects;

v) encouraging local fabrication of equipment and tools which will help to improve spare parts supply from local sources thereby helping to minimize equipment-related maintenance problems.

Community participation

44. Community participation has assumed increasing importance particularly with regard to infrastructure provision in rural areas, as well as in slums and squatter settlements in the urban areas. The objective is to design the project so as to make use of financial, technical and organizational resources that are available in the local community for whom the infrastructures are being provided. Experience from countries in the region show that many successful sites and services projects and community water supply schemes have benefited greatly from the involvement of the local community in the conception, design, construction and maintenance of the facilities. This involvement has also been a vehicle for rapid dissemination and adoption of appropriate technologies.

45. Another benefit of local community participation in infrastructural projects is the lowering of construction cost through the provision of voluntary labour. In some rural water supply schemes in Tanzania, labour provided through self-help accounted for between 10 and 30% of the total construction cost. 4/

46. Technological choice should therefore give due cognizance to the potential for involving the local community, which means that the level of technology prescribed should be that which the community can master after the necessary in-situ training and demonstration. For this to succeed, there should be strong and functional community organizations. The project formulation should make provision for giving the necessary institutional support to strengthen and enhance the effectiveness of such organizations.

Cost

47. The construction and maintenance of infrastructures in human settlements using conventional technologies involve large capital outlays. For example, the capital costs of community water supply projects are estimated to be: $US 10 - 30 per capita for groundwater schemes based on handpumps; $US 30 - 60 per capita for standpipe supplies, and $US 60 - 110 for yardtap services 5/. The high cost of investment requirements would make it almost impossible for most African governments to provide basic infrastructures to the vast majority of the population. Technologies which would reduce the current high per capita cost of infrastructure provision should therefore be accorded priority in project design and construction.

48. In a water supply project started in 1985 to provide 290 protected water points to the 300,000 inhabitants of Epworth, a peri-urban settlement close to Harare(Zimbabwe), the residents were provided technical supervision to use locally manufactured hand-operated drilling rigs to tap underground water. Locally designed and manufactured pumps were then installed. Once completed, the 290 installations would deliver a total of over 600,000 litres of potable water per day at an installation cost of less than Z$4.00 (about $US2.00) per capita, which is really low-cost 7/.

49. In considering cost as a criterion for technology selection, the potential for financial contributions from the local community could be vital. The communal spirit is strong in the rural areas of many countries and examples abound of village and town development committees which have taken the initiative to mobilize capital from local contributions which are then matched by funds from central governments to provide much needed infrastructure like water supply, sanitation facilities and electric power supply.

50. The cost criterion should also be viewed in terms of the ability and willingness of consumers to pay for the services to be provided in the case of infrastructure for which user charges would be levied.

Recommendations for Action

51. The resources needed to provide human settlements infrastructures in both the urban and rural areas of Africa are enormous. The concern of governments to address the infrastructure problem is equally great. It is important therefore that available resources are used efficiently to reach the greater number of people. The selection and application of appropriate design and construction technologies is therefore of vital importance and should constitute a vital component of human settlements programmes in the region. The following actions are recommended for the attention of member States.

At the national level

i) Promote the utilization of appropriate technologies in locally funded projects as well as in externally supported infrastructure projects,

ii) Encourage the development of local capacities for the fabrication of equipment and tools needed in support of appropriate infrastructure technologies;

iii) Provide technical assistance to community groups to utilise low-cost technologies in infrastructure projects;

iv) Strengthen existing institutions or set up appropriate institutions to organize training at different levels,

v) Encourage research on the development of low-cost and appropriate infrastructure technologies and support their utilization, initially in pilot projects;

vi) Promote the inclusion of courses in appropriate infrastructure technologies in the curricula of professional educational institutions;

vii) Encourage professionals to adopt designs and construction technologies that emphasize the utilization of locally available resources,

viii) Review existing design and construction standards and specifications which could inhibit the acceptance of proven technologies that lead to lower costs in infrastructure provision;

ix) Provide opportunities for the training of local contractors in innovative low-cost technologies;

x) Provide adequate institutional and financial support for the maintenance of infrastructures to ensure maximum benefits from the utilization of appropriate technologies;

xi) Initiate and support education programmes that would promote improved health conditions, in conjunction with the provision of critical health-related infrastructures like water supply and sanitation;

xii) Organize country-wide dissemination of low-cost infrastructure technologies by giving wide publicity to projects in which they are utilized;

xiii) Establish a mechanism for the sharing of information and experiences with other countries in the region.

At the regional and international levels

52. Regional and international organizations have a role to play in assisting African countries in their programmes to increase the coverage of basic infrastructures with limited resources. Their resources, including finance and experience acquired in other third world countries must be used to support the efforts of the governments of African countries. Specifically their assistance would be required in the following areas:

i) Encourage the adoption of appropriate technologies in the design and construction of infrastructure projects for which external funding is provided, giving due consideration to the need to maximize the use of local resources;

ii) Support research and development on innovative and low-cost technologies;

iii) Assist in training technicians and professionals both locally and abroad;

iv) Assist in the development of design standards and specifications as well as relevant codes of practice in support of appropriate technologies;

v) Assist in setting up or strengthening existing local capacities for the manufacture of equipment and tools;

vi) Promote information exchange among African countries and also between them and countries outside the region.

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Table 1. Options for Community Water Supply

Step	Type of Service	Water source	Quality protection	Water use LPCD[a]	Energy source	Operation and maintenance needs	Costs	General remarks
5	House Connections	Groundwater Surface water Spring	Good, no treatment May need treatment Good, no treatment	100 to 150	Gravity Electric Diesel	Well-trained operator; reliable fuel and chemical supplies; many spare parts; wastewater disposal	High capital and O&M costs, except for gravity schemes	Most desirable service level, but high resource needs
4	Yardtaps	Groundwater Surface water Spring	Good, no treatment May need treatment Good, no treatment	50 to 100	Gravity Electric Diesel	Well trained operator; reliable fuel and chemical supplies; many spare parts	High capital and O&M costs, except gravity schemes	Very good access to safe water; fuel and institutional support critical
3	Standpipes	Groundwater Surface water Spring	Good no treatment May need treatment Good, no treatment	10 to 40	Gravity Electric Diesel Wind Solar	Well trained operator; reliable fuel and chemical supplies; many spare parts	Moderate capital and O&M costs, except gravity schemes; collection time	Good access to safe water; cost competitive with handpumps at high pumping lifts
2	Handpumps	Groundwater	Good, no treatment	10 to 40	Manual	Trained repairer; few spare parts	Low capital and O&M costs; collection time	Good access to safe water; sustainable by villagers
1	Improved traditional sources (partially protected)	Groundwater Surface water Spring Rainwater	Variable Poor Variable Good, if protected	10 to 40	Manual	General upkeep	Very low capital and O&M costs; collection time	Improvement if traditional source was badly contaminated
0	Traditional sources (unprotected)	Surface water Groundwater Spring Rainwater	Poor Poor Variable Variable	10 to 40	Manual	General upkeep	Low O&M costs (buckets, etc); collection time	Starting point for supply improvements

a/ LPCD - litres per capita per day
Source :S. Arlosoroff et.al :Community water supply - the handpump option. World Bank, 1987.

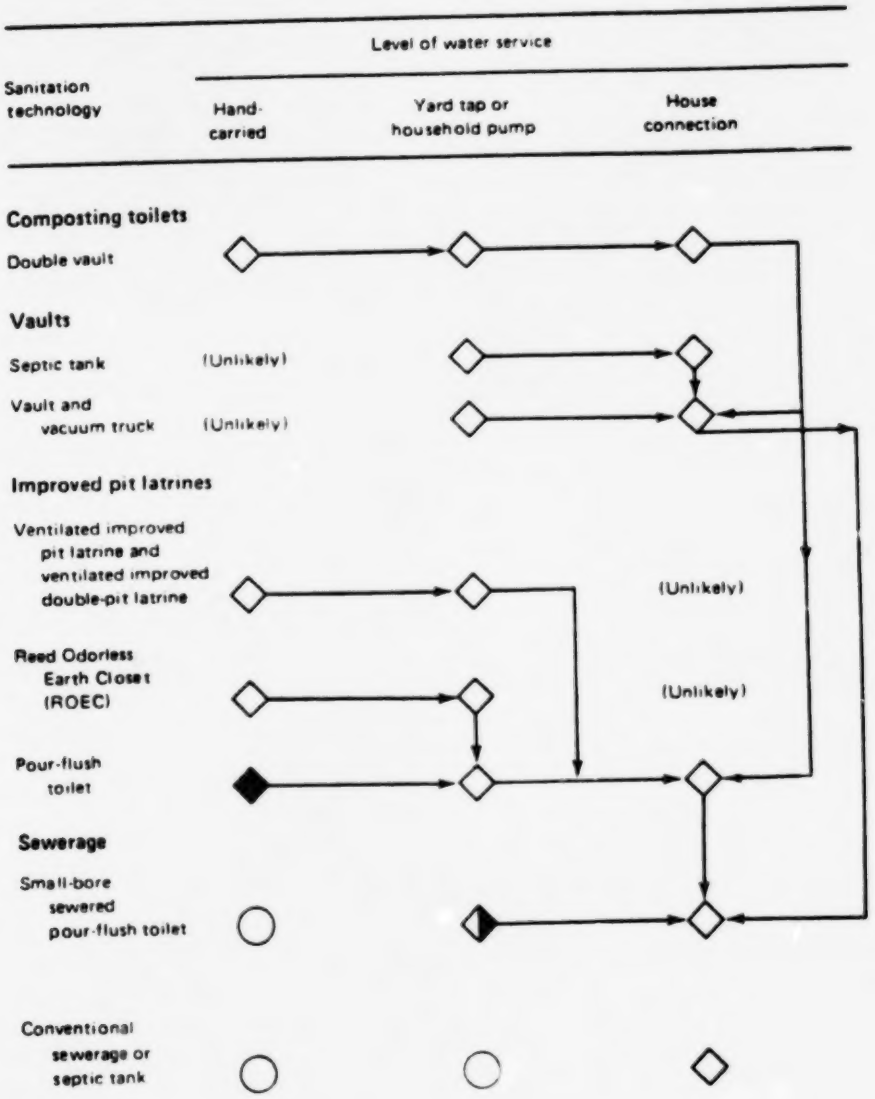
Table 2 Descriptive comparison of sanitation technologies

Sanitation technology	*Rural application*	*Urban application*	*Construction cost*	*Operating cost*	*Ease of construction*	*Self-help potential*	*Water requirement*	*Required soil conditions*	*Complementary off-site treatment*[a]	*Reuse potential*	*Health benefits*	*Institutional requirements*
Ventilated improved pit (VIP) latrines and Reed Odorless Earth Closets (ROECS)	Suitable	Suitable in L/M-density areas	L	L	Very easy except in wet or rocky ground	H	None	Stable permeable soil; groundwater at least 1 meter below surface[b]	None	L	Good	L
Pour-flush (PF) toilets	Suitable	Suitable in L/M-density areas	L	L	Easy	H	Water near toilet	Stable permeable soil; groundwater at least 1 meter below surface[b]	None	L	Very good	L
Double vault composting (DVC) toilets	Suitable	Suitable in L/M-density areas	M	L	Very easy except in wet or rocky ground	H	None	None (can be built above ground)	None	H	Good	L
Self-topping aquaprivy	Suitable	Suitable in L/M-density areas	M	L	Requires some skilled labor	H	Water near toilet	Permeable soil; groundwater at least 1 meter below surface[b]	Treatment facilities for sludge	M	Very good	L
Septic tank	Suitable for rural institutions	Suitable in L/M-density areas	H	H	Requires some skilled labor	L	Water piped to house and toilet	Permeable soil; groundwater at least 1 meter below surface[b]	Off-site treatment facilities for sludge	M	Very good	L
Three-stage septic tanks	Suitable	Suitable in L/M-density areas	M	L	Requires some skilled labor	H	Water near toilet	Permeable soil; ground water at least 1 meter below surface[b]	Treatment facilities for sludge	M	Very good	L
Vault toilets and cartage	Not suitable	Suitable	M	H	Requires some skilled labor	H (for vault construction)	Water near toilet	None (can be built above ground)	Treatment facilities for night soil	H	Very good	VH
Sewered P1 toilets, septic tanks, aquaprivies	Not suitable	Suitable	H	M	Requires skilled engineer/builder	L	Water piped to house and toilet	None	Sewers and treatment facilities	H	Very good	H
Sewerage	Not suitable	Suitable	VH	H	Requires skilled engineer/builder	L	Water piped to house and toilet	None	Sewers and treatment facilities	H	Very good	H
Shallow sewerage	Not suitable	Suitable	L	L	Requires skilled engineer builder	M	Water near toilet	None	Sewers and treatment facilities	H	Very good	M

Source: J.M. Kalbermatten, and others, Appropriate Sanitation Alternatives: A Planning and Design Manual (Baltimore, Johns Hopkins University Press, 1982), p. 160 (modified to include shallow sewerage).

Notes: L, Low; M, medium; H, high; VH, very high
a. On- or off-site sullage disposal facilities are required for nonsewered technologies with water service levels in excess of 50 to 100 lcd, depending on population density.
b. If groundwater is less than 1 metre below the surface, a plinth can be built.

Figure . 1 Potential Sanitation Sequences



◇, Technically feasible. ◆, feasible if sufficient pour-flush water will be hand carried.
○, Technically infeasible. ◑, feasible if total wastewater flow exceeds 50 liters per capita daily.

Source :J.M. Kalbermatten et.al :Appropriate Technology for water supply and sanitation - A planner's guide (p.63) World Bank. 1980.